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**The attached papers are a true and exact copy of the originally filed documents of
this patent application.**

Munich, the 13th day of August 2004
German Patent and Trademark Office

The President

by:

(signature)

(printed name)

Annular composite workpieces and a cold-rolling method for their production

Description

The invention relates to annular composite workpieces, in particular rolling bearing rings, and a cold rolling method for their manufacture from at least two hollow cylindrical workpieces made of different materials or the same materials with different strength (in the following different materials).

Occasionally the production of this kind of rolling bearing rings is described in the literature.

According to DE 200 923, an unhardened reinforcement ring is placed over a hardened ring after it has been finish-machined and filled with balls. It is pointed out that the bearing can accept more balls because the hardened ring deforms elastically when filled. A bonded material structure and thus sufficient dynamic loadability cannot be reached with this solution.

In DE 27 45 527, the production of outer rings of rolling bearings by using cold rolling is described. Two rings with exactly the same volume made of different materials are fixedly connected to one another by shrinking, then roll formed, and afterwards finish-machined by turning on the outside and grinding. The advantages are above all seen in the combination of the material characteristics, here above all in the combination of a ball race of great hardness with excellent wear characteristics and a support ring of reduced hardness and strength that can then be processed more easily. During forming, the rings are deformed together tangentially, radially and axially at the same time. A fast connection of both rings is reached only in exceptional cases. Different materials generally have different expansion capacities so that the rings tend to separate (the shrink connection separates) rather than to remain fixed together. For the technical implementation of the method, a complex tool configuration made of several divided tool parts is necessary. The costs are

high; the production spectrum is limited and greatly curtailed in regard to complicated profile cross sections. In spite of the obvious advantages resulting from the potentially higher practical value of the composite rolling bearings, no large scale application of DE 27 45 527 is known.

The object of the invention is to efficiently produce annular composite workpieces, especially for high dynamic loads, made of at least two hollow cylindrical workpieces.

According to the invention, the object is by a method with the features mentioned in the preamble of claim 1 in that the hollow cylindrical workpieces are formed to a composite workpiece by means of a generally known axial roll forming method.

Furthermore, the object is solved by an annular composite workpiece with the features claimed in claim 7.

Advantageous variations and embodiments are the subject matter of the dependent claims.

Axial roll forming methods are known since 1972 at the latest. "When rolling, the material that is compressed by the penetration of the profile transversely to the axial direction of the workpiece is displaced laterally so far outwardly that across the original width of the workpiece ... protruding lateral boundary edges are formed." (DE 22 08 515 A1, page 2)

It was found that the at least two workpieces are fixedly connected to each other even when they had been placed only loosely into each other beforehand and had not been shrunk onto each other. The composite shows characteristics of a cold pressure welding connection; these characteristics are the result of pressing together the surfaces of the workpieces at very high pressure.

The workpieces preferably have such a play relative to one another that they can barely be joined by hand.

Since such a play is permissible, pipes, i.e. longer hollow cylindrical workpieces, can also be fit together in an uncomplicated manner.

Therefore, both the axial roll forming of rings (e.g. DE 22 08 515) as well as the axial roll forming of pipes (e.g. DD 225 358 or DE 195 26 900) can be employed. With the latter method, the composite rings may be produced especially efficiently and in a material saving way.

Both profiled outer and inner rolling bearing rings can be produced. The bearing races are made of high quality antifriction bearing steel, respectively. The support rings in contrast are made of a steel which is not as strong, which is cheaper and can be machined more easily, so that the overall costs for the rolling bearing ring are significantly lowered.

Also, composite rings made of steel in combination with nonferrous metals, in particular aluminum, can be produced, for example, for lightweight construction or for corrosion protection. Because the material selection is matched to the function, production costs are saved to a considerable extent and new use characteristics are obtained.

The invention will be explained in more detail in the following with the aid of several embodiments based on the axial roll forming of pipes. The drawings show in:

Fig. 1 preparation of the pipes to be rolled,

Fig. 2 production of inner rings of rolling bearings from two pipes,

Fig. 3 an individual inner ring of rolling bearings made from two pipes,

Fig. 4 production of inner rings of rolling bearings from three pipes,

Fig. 5 production of a gear ring from two hollow cylindrical workpieces,

Fig. 6 production of outer rings of rolling bearings from two pipes.

According to Fig. 1, two pipes as workpieces 1 and 2 are prepared for forming. They

are, if necessary, turned on the outside and turned on the inside and then inserted into one another.

In Fig. 2, the two workpieces 1 and 2, embodied as pipes, are positioned on a rolling arbor 7 between two roll forming tools 6 for forming an outer profile. The rolling tools 6 for forming an outer profile are diametrically opposed, are rotatable, and can be radially advanced. In addition, they are axially movable in order to follow the pipe elongations caused by axial material flow.

Fig. 3 shows the composite inner ring 8 of a rolling bearing completely ready for grinding after the steps of cropping and machining by cutting. The original pipes now form the bearing race 1', e.g. made of high-strength antifriction bearing steel, and the thrust ring 2' made of steel which is not as strong and easier to machine.

Fig. 4 shows the production of a composite inner ring 9 of a rolling bearing made of three workpieces 3, 4 and 5. The workpieces 3 and 5, formed as pipes, consist of different steels in analogy to the first variant; workpiece 4 is made of aluminum. It can intentionally be kept thick (lightweight construction) or can be only a thin, e.g. vapor-deposited, layer in order to promote the connection of the workpieces 3 and 5 during rolling of the composite in analogy to cold pressure welding.

Fig. 5 shows the production of a gear ring 10 from two workpieces 1 and 2 with two roll forming tools 6 for forming an outer profile and a rolling arbor 7. The workpieces 1 and 2 are made of steel materials of different strength.

Fig. 6 shows the production of a composite outer ring 11 of a rolling bearing. The high-strength workpiece 1 forms again the bearing race and is now located on the inside in comparison to Fig. 2 or Fig. 3.

In all variants, it is ensured that the material, above all in the area of the bordering layers, can flow freely axially almost during the entire forming process.

List of reference numerals

- 1 - workpiece
- 1' – bearing race
- 2 - workpiece
- 2' – support ring
- 3 - workpiece
- 4 – workpiece
- 5 – workpiece
- 6 – roll-forming tool for forming outer profile
- 7 – rolling arbor
- 8 – composite inner ring of rolling bearing
- 9 – composite inner ring of rolling bearing
- 10 - gear ring
- 11 – composite outer ring of rolling bearing

Claims

1. Cold rolling method for the production of an annular composite workpiece made of at least two hollow cylindrical workpieces made of different materials which are roll formed together, **characterized in that** the hollow cylindrical workpieces (1 to 5) are formed by means of a generally known axial roll forming method to a composite workpiece (8 to 11).
2. Method according to claim 1, **characterized in that** the hollow cylindrical workpieces (1 to 5) are inserted loosely into each other before rolling.
3. Method according to claims 1 and 2, **characterized in that** the hollow cylindrical workpieces (1 to 5) have such a play relative to one another that they can barely be joined by hand.
4. Method according to claim 1, **characterized in that** rings as hollow cylindrical workpieces (1 to 5) inserted into each other are formed to a composite workpiece (8 to 11) by an axial ring roll forming method.
5. Method according to claim 1, **characterized in that** pipes as hollow cylindrical workpieces (1 to 5) inserted into each other are formed by an axial pipe roll forming method to a composite workpiece (8 to 11).
6. Method according to claim 1, **characterized in that** at least one of the surfaces touching one another of the hollow cylindrical workpieces (1 to 5) is coated with a material, e.g. aluminum.
7. Annular composite workpiece, comprised of at least two hollow cylindrical workpieces made of different materials, **characterized in that** the composite workpiece (8 to 11) is produced by an axial roll forming method.

8. Composite workpiece according to claim 7, **characterized in that** the composite workpiece is a bearing ring.
9. Composite workpiece according to claim 8, **characterized in that** the bearing race (1') of the bearing ring is made of antifriction bearing steel and the support ring (2') is made of a steel of reduced high strength.
10. Composite workpiece according to claim 7, **characterized in that** the composite workpiece is a gear ring.
11. Composite workpiece according to one of the claims 7 to 10, **characterized in that** one of the workpieces (1 to 5) is comprised of a nonferrous metal, in particular aluminum.
12. Composite workpiece according to one of the claims 7 to 11, **characterized in that** one of the workpieces (1 to 5) is made of plastic material.
13. Composite workpiece according to one of the claims 7 to 12, **characterized in that** one of the workpieces (1 to 5) is made of powder material.

In connection with 3 drawing sheets

Abstract

Annular composite workpieces and a cold-rolling method for their production

The invention concerns a cold rolling method for manufacturing annular composite workpieces, in particular rolling bearing rings, from at least two hollow cylindrical workpieces made of different materials or the same materials with different strength. According to the invention, the hollow cylindrical workpieces are loosely inserted into each other and formed by means of an axial ring or pipe roll forming method to a composite workpiece. The at least two workpieces are permanently fixedly connected to each other in the annular composite workpiece. Combinations of different steels or with non-ferrous metals, especially aluminum, can be realized. By a material selection matched in accordance with function, production costs are saved to a considerable extent and new use characteristics are obtained.

Fig. 2